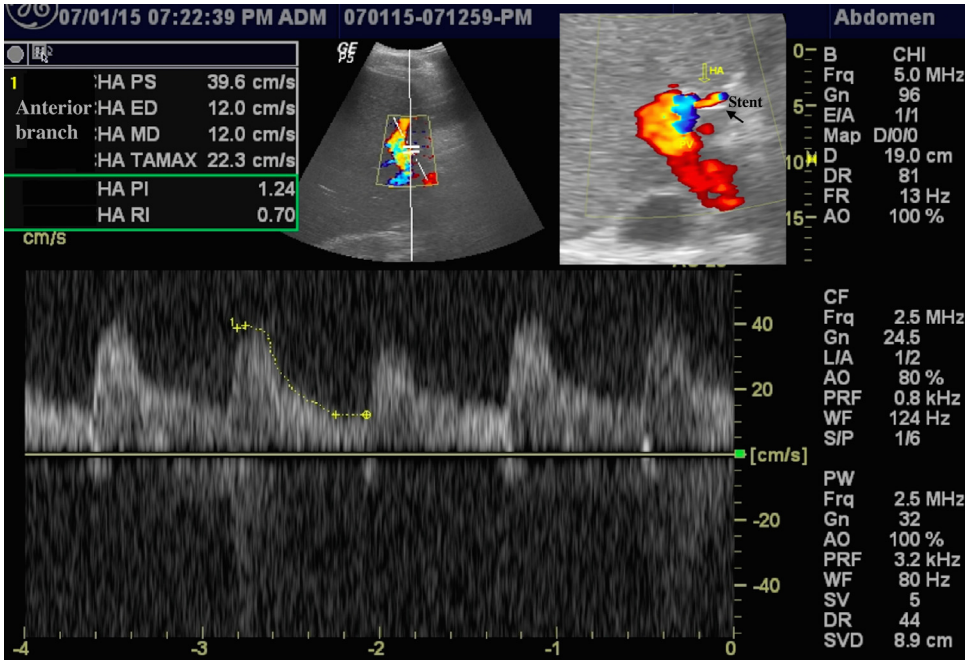

Figure 6. Color Doppler image obtained 4 months and one week postoperatively, confirming stent patency and normal flow in the anterior segmental branch. The posterior branch was occluded.

of fresh frozen plasma over 4 days. Aspirin therapy was begun after the seventh postoperative day at 150 mg/d. On day 15 postoperatively, Doppler ultrasound and computed tomography angiography revealed occlusion of the posterior segmental branch of the hepatic artery, with normal flow in the main graft artery and its anterior branch. There were also areas of congestion in segments V and VIII and a 5-cm infarct in segment VI.

Initial postoperative graft dysfunction occurred with marked elevation in aminotransferase and bilirubin levels: alanine aminotransferase, 2,844 IU/L; aspartate aminotransferase, 4,736 IU/L; and bilirubin, 22.5 mg/dL. The elevated transferase returned to normal levels and bilirubin reached 2 mg/dL 3 weeks postoperatively. The graft dysfunction was attributed to early venous congestion, possible ischemic injury from prolonged surgery, and compromise of the posterior branch of the graft artery later on. The patient was discharged from the intensive care unit 25 days postoperatively. Additional anastomotic biliary leakage was managed by failed endoscopic stent placement, then hepaticojejunostomy on postoperative day 52. The patient was discharged from the hospital on postoperative day 82.

At the 4-month and 1-week postoperative follow-up examination, the stent and the anterior branch of the graft artery were patent with normal flow (Fig 6), and the posterior branch remained occluded. There was liquefaction in the infarct without signs of infection, and expected segmental biliary strictures had not yet developed.

Our experience of 550 LDLTs includes endovascular intervention in 16 patients with early postoperative hepatic artery thrombosis. We believe that angioplasty and stent placement of a fresh hepatic artery anastomosis carries a high risk of complications, including spasm, further dissection, and perforation, which are common in the first 48 hours postoperatively. Although the long-term patency of the stent remains in question in our case, with comorbidities including coagulopathy, there was an emergent need to salvage the graft. We also had the advantage of open surgical backup.

In conclusion, hybrid surgical reconstruction of the hepatic artery and endovascular stent placement is possible and effective for graft salvage in LDLT. Proper tailoring of antiplatelet therapy is crucial in the perioperative period to ensure long-term stent patency.

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Endurant Endograft Limb Occlusion Associated with a Floating Thrombus: A Word of Caution

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Editor:

Aortic endograft thrombotic occlusion after endovascular aortic repair (EVAR) is uncommon, with an incidence between 0 and 7%, and mostly occurs within the first 2 months after EVAR. We encountered three patients with progressive formation of a floating thrombus in the right iliac limb of a new-generation modular stent graft (Endurant; Medtronic, Minneapolis, Minnesota), occurring at different time intervals after initial EVAR. Institutional review board approval was waived for these case reports.

In the first case, a 60-year-old man presented with a 55-mm-diameter asymptomatic infrarenal abdominal aortic aneurysm (AAA) and was treated endovascularly with an Endurant modular aortic stent graft. After the procedure, the patient was prescribed lifelong acetylsalicylic acid at a daily dosage of 80 mg. Follow-up computed tomography (CT) scans performed at 6 and 12 months after initial EVAR revealed a small, focal, floating thrombus at the distal end of the right iliac stent graft limb. Clinically, the patient was symptom-free, and a strict regimen of antiplatelet therapy was continued. The patient developed right-sided intermittent claudication 18 months after EVAR, which was associated with distal migration of the growing floating thrombus into the deep and superficial femoral artery. It was decided to treat the patient's claudication conservatively by adding coumarins to the antiplatelet drug regimen for 12 months. At 30 months after EVAR, CT scan revealed a formation of new thrombotic material in the right limb of the stent graft, which was managed by relining the right limb of the stent graft with a 24-mm distal diameter Dacron-based limb extension (Endurant contralateral limb and limb extension; Medtronic). CT scan performed 1 year later after relining the right limb revealed a newly formed floating thrombus in the relined right stent graft limb. It was decided to treat the clot formation by relining the right limb a second time with the use of an expanded polytetrafluoroethylene (e-PTFE) stent graft limb with a nominal diameter of 27 mm (GORE EXCLUDER limb; W. L. Gore & Associates, Flagstaff, Arizona). Regular clinical and follow-up over 24 months showed absence of formation of thrombotic deposits in the stent graft body or limbs.

In the second case, a 65-year-old man presented with a 58-mm-diameter asymptomatic AAA, which was successfully excluded with a Dacron-based modular stent graft (Endurant). The postoperative course was uneventful, and the patient was prescribed lifelong acetylsalicylic acid at a daily dosage of 80 mg. On the 6-month follow-up CT scan, a floating thrombus was identified in the right limb of the stent graft (**Fig a, b**). The patient had no symptoms of claudication at that time. It was decided to reline the right stent graft limb with an e-PTFE covered stent graft limb (GORE EXCLUDER limb) with a length of 95 mm and a distal diameter of 20 mm. The patient recovered well without residual symptoms. The patient presented 2 years after the initial EVAR procedure with severe contralateral (left-sided) claudication. Radiologic investigation revealed an occluded left tibiofibular trunk, potentially related to distal embolization. Abdominal CT scan could not demonstrate thrombotic material within the body or left limb of the stent graft. The patient was treated by percutaneous recanalization and angioplasty of the tibiofibular trunk; early recurrence of symptoms occurred, and conservative management including exercise therapy and continued antiplatelet therapy was prescribed. Serial follow-up CT scans of the endograft over a 2-year period did not reveal any newly formed

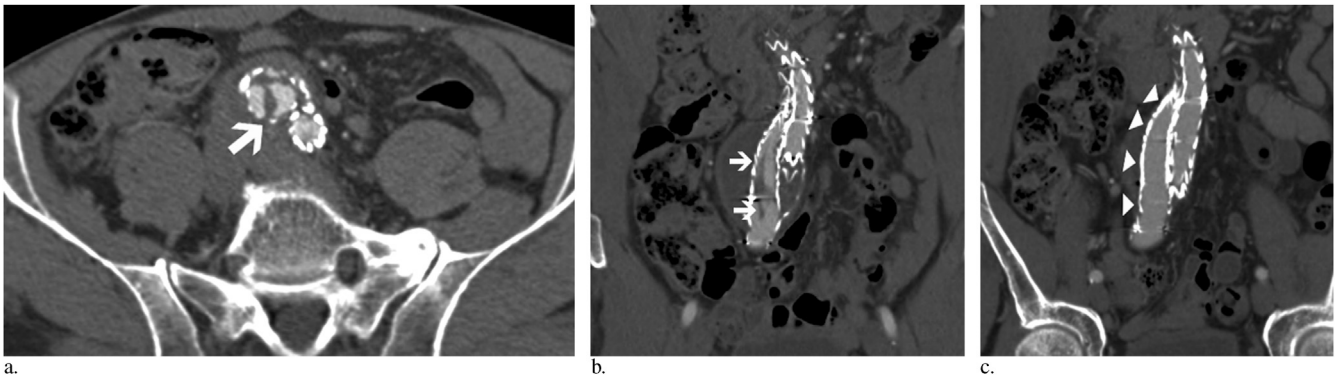

Figure. **(a)** Axial CT scan performed 6 months after EVAR reveals a floating thrombus (arrow) in the right stent graft limb. **(b)** Corresponding coronal CT reconstruction shows the floating thrombus (arrows) in the distal part of the right stent graft limb. **(c)** Axial CT scan performed 2 years after relining with an e-PTFE-covered Excluder stent graft limb shows absence of any thrombotic material in the right relined stent graft limb (arrowheads).

thrombotic deposits in the stent graft body or either of the limbs (**Fig c**).

In the third case, a 58-year-old man presented with an asymptomatic, 55-mm-diameter infrarenal AAA, which was successfully excluded by endovascular techniques using a modular Dacron-based stent graft (Endurant). After the procedure, the patient was prescribed lifelong acetylsalicylic acid at a daily dosage of 80 mg. CT scan performed 2 years after EVAR revealed a stable aneurysmal sac diameter, a discrete inflammatory layer around the AAA, and a small newly formed floating thrombus in the right limb of the stent graft. Follow-up CT scan performed 6 months later showed clear growth of the floating thrombus, although the patient remained asymptomatic. At that time, it was decided to reline the right limb of the stent graft with a 27-mm-distal-diameter e-PTFE-covered stent graft limb (GORE EXCLUDER limb). Follow-up CT scans performed over 1.5 years did not reveal any recurrent clot formation in the stent graft limb, and clinically the patient is doing well.

The presence of a floating thrombus in the thoracic or abdominal aorta in general or in an aortic endograft in particular is very rare. In a cohort of 496 patients treated with the Endurant stent graft, van Zeggeren et al (1) identified two cases of floating thrombus formation. These authors did not comment on further treatment and outcome. The incidence of asymptomatic circumferential thrombotic deposits in endografts has been studied better, and these may occur in 30% of cases (2); complete endograft limb occlusion may occur in 1%–5% when using currently available endografts (1,3). In patients treated with the Endurant stent graft for infrarenal aortic aneurysms, the incidence of complete thrombotic limb occlusion is between 1% and 4% (1,4). Complete limb occlusion most commonly occurs during the first 60 days after stent graft insertion. In 60% of cases, a technical error during the initial EVAR procedure was considered to be the cause of the occlusion, including extreme stent graft oversizing, positioning of the endograft limb in a kink of the iliac vessel, performing the completion angiogram without removing the stiff guide wire, overlooking indications for balloon angioplasty distal to the stent graft limb (1), or using a long small-diameter stent graft landing in the external iliac artery (3). In the first and third cases presented, the floating thrombus was identified on a CT scan performed 2 years after EVAR. In all three cases, a floating thrombus was identified that was only partially occluding the stent graft limb. None of the patients had other serious comorbidities, including hemostatic disorders, or experienced paraneoplastic or other cancer-related complications. Finally, we could not find any technical or anatomic cause of clot formation because in all three cases the stent graft was planned in accordance with current guidelines and instructions for use. There was no limb kinking or distal iliac stenosis, and the stent graft landed in a relatively large and nontortuous common iliac artery.

Treatment of a floating thrombus within a stent graft limb is challenging. In the first case, we initiated medical anticoagulation treatment with coumarins; however, the floating thrombus did not disappear, and distal embolization developed. Relining with another Endurant stent graft limb was performed. The patient presented with a newly formed floating thrombus in the relined limb 1 year after reintervention. At that time, large-bore e-PTFE-covered stent graft limbs became available on the market, and a GORE EXCLUDER stent graft limb with a nominal diameter of 27 mm was used to reline the Endurant stent graft limb a second time. This technique of relining the Endurant limb with an e-PTFE-covered EXCLUDER limb, completely trapping the floating thrombus in between the two layers of the stent graft limbs, seems very effective: Recurrent thrombus formation was not detected in any of the cases on serial follow-up CT scans after 2, 2, and 1.5 years. The reason a Dacron-based Endurant stent graft might rarely be associated with a floating thrombus in an endograft limb is unclear, although early experimental reports suggested that e-PTFE is less thrombogenic than Dacron-based grafts. It also was demonstrated that circumferential clot formation occurs more frequently in Dacron-based stent grafts compared with e-PTFE-based stent grafts (3).

In conclusion, late formation of a floating thrombus in an Endurant stent graft limb without clear technical, anatomic, or biochemical predisposing factors for clot formation may occur. This floating thrombus may be resistant to medical and anticoagulation therapy and may reappear after relining with another Dacron-based stent graft limb. Conversely, relining with e-PTFE-covered stent graft limbs might be a better and more durable treatment option to manage a floating thrombus in an Endurant stent graft limb, but longer follow-up in more patients is needed to reach a definitive conclusion.

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